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SOVIET USE OF HARD-ALLOY DIAMOND SUBSTITUTES IN SIZE-CONTROL INSTRUMENTS

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The tips of instruments which control the size of parts in the machining process on grinding machines are subjected, during the working period, to constant pressure against the surface of the part under control. The amount of change in the size of the part is transmitted by a system of levers to a minimeter, from which readings are taken. The friction of the tips against the surface of the part being ground, and friction with the abrasive dust from the grinding wheel, cause abrasion on the tips, which results in a marked error in the readings of the instrument. Consequently, the material used on the tips must have high abrasion-resistance.

Diamond has been used for this purpose up to now, but because it is scarce and costly, the problem of finding a substitute has arisen. Experiments have been carried out to determine the abrasion-resistance of hard, metallo-ceramic alloys, domestic and foreign, of relit /fused tungsten carbide/, and of synthetic ruby /corundum/.

Plates with a 2.5 x 2.5 millimeter cross section, of the materials under study, were welded to the tips of instruments for controlling holes during grinding. The instruments had two tips; one was placed in a hole in the part above the grinding wheel, and the other under the wheel. When the rubbing became comparatively steady, the instruments began to register.

The extent of wear was determined in the following way: A standard part, into which the tips of the instrument were inserted, was fastened to the chuck of the machine tool. A reading, which corresponded with the size of the standard, was produced on the minimeter within an accuracy of 1 micron. Then the standard was removed and a given batch of parts machined. After this, another reading was taken from the standard. The difference between the first and last readings of the minimeter is equal to the total abrasion on the two tips of the instrument, caused by machining a given batch of parts.

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The materials tested can be divided into two groups, according to the nature of the abrasion. To the first group belong those which sustain a variable, irregular abrasion: ruby, relit, and hard alloy T60K6. The composition of T60K6 and of relit is distinguished by considerable porosity; the size of the pores and their distribution are extremely heterogeneous. This is apparently the cause of their spasmodic abrasion. The irregular abrasion of ruby is due to the chipping which occurs along the cleavage plane. All these materials sustained cracks on the working surface during the testing process.

The second group, which undergoes uniform abrasion, includes all the other hard alloys. Titanium alloys showed less resistance to abrasion than tungsten alloys. The abrasion-resistance of alloys increased with a decrease in the percentage of cobalt content, that is, with an increase in hardness.

Research was conducted simultaneously on the abrasion-resistance of foreign hard alloys taken from instruments produced by the American firms, Landis and Arnold, and the Swedish SKF plants. The abrasion-resistance of domestic alloys proved to be higher than that of foreign alloys of similar composition and structure.

Highest abrasion-resistance was shown by alloy $VK6^a$ from the scientific research laboratory of the Moscow Hard Alloys Combine. It is distinguished from alloy VK6 by its greater degree of hardness and durability, which depend upon the fine-grained, compact structure. The extent of abrasion on alloy $VK6^a$ was within the limits allowed for the machining of parts. Instruments in all the shops of the plant, including precision instruments, were tipped with alloy $VK6^a$. Observations on the work of the instruments during a 2-month period showed positive results. Alloy $VK6^a$ is now being used at the plant on the tips of all instruments designed for size-control in the machining process, as well as for the friction surfaces of stationary measuring instruments.

Variation in the abrasion-resistance of materials was closely related to changes in the surface finish of the tips during the testing process. After the testing, the working surface of all the titanium alloys had become dull, the lower tips were rather rough, and the upper tips had shallow graduation lines. The greater the abrasion-resistance of the alloy, the smoother its surface finish. Thus, after the tests on alloy $VK6^a$, the working surface of the tip shone as if it had been polished.

The upper tip, as a rule, developed much sharper graduation lines. The longer the tip was in operation, the more noticeable and distinct the lines became. After upper tips of $VK6^a$ alloy had been in continuous operation for 1 month, the direction of the lines on all the test models was identical. They were parallel and tangential to the direction of the movement of the part.

In measuring the abrasion on the tips in the working process, it became apparent that the upper tip undergoes more wear than the lower. Of the total abrasion of 14 microns, abrasion of the upper tip was responsible for 10 microns, because the tests were conducted during rough grinding of parts which had undergone only turning, and which had coarse ridges. During the grinding, the abrasive dust becomes lodged between the ridges, and under the pressure of the instrument tip, grinds out depressions in it in the direction of the movement of the part.

The formation of the graduation lines on the tip is the result of friction against the abrasive dust, and not the steel. This is confirmed, first, by the fact that the abrasion-resistance of the tungsten alloys, particularly alloy $VK6^a$, was highest, whereas the titanium alloys, which were intended for the machining of steel, sustained a greater degree of abrasion. It is confirmed also by the greater degree of abrasion on the upper tip. During the grinding, a spray of cooling emulsion was directed in such a way that the abrasive dust did not fall under the lower tip of the instrument, but continued to fall under the upper tip.

In an examination of the curves for the alloys composed of 94 percent tungsten carbide and 6 percent cobalt, the group of fine-grained alloys, mark VK6[a], showed by far the least abrasion. Highest abrasion-resistance was shown, respectively, by alloys with a WC /tungsten carbide/ grain-size of 0.5 microns, 3-6 microns, and 1 micron. Curves for the coarser-grained alloys, mark VK6, indicated less abrasion-resistance. There is no difference in the WC grain size of alloys VK6 and VK6*, but the difference in abrasion-resistance of these alloys is greater than in the case of the VK6[a] specimens. Hence, the WC grain size alone does not determine the abrasion-resistance of the alloy.

Another important factor is the completeness of formation of the alloy in the sintering process. In the case of tungsten alloys of low cobalt content, the forming of the alloy during sintering depends first upon the reaction of the cementing metal (cobalt), and the tungsten carbide, and next, upon the nature of the carbide shell which develops in the final stage of sintering.

The presence of a carbide shell is of great importance for resistance to abrasion. The abrasive dust will grind out the soft component of the alloy, cobalt, and the durability of the worn working surface will depend to a great extent on the durability of the carbide shell. This probably explains the fact that abrasion-resistance decreases with an increase in the percentage content of cobalt in the alloy.

In a 15-percent cobalt alloy (VK15), the carbide shell will develop most poorly, and for this reason, the abrasion-resistance of this alloy is lowest. A fine-grained alloy has a well-developed carbide shell, and therefore high resistance to abrasion.

To regulate the completeness of the sintering process at the Moscow Hard Alloys combine, workers cut the part into equal halves, testing the hardness on the surface and in the center of the cross section. A comparison of the two hardness values shows that completeness of formation of the alloy in sintering is achieved to a greater extent in alloy VK6[a] with a 0.5-micron grain, and in VK6*.

Thus, in the case of identical WC grain sizes, the alloy whose hardness was identical in every cross section, that is, the alloy whose formation in the sintering process was most complete, had the highest resistance to abrasion.

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